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An acoustic and perceptual analysis of adaptation to an EPG artificial palate

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Electropalatography

- Has provided valuable insights into the dynamics of tongue-palate articulation in children and adults

- Shown positive treatment outcomes for children with articulation disorders (Carter & Edwards, 2004; Gibbon et al., 1993; 2003)

- Requires the use of a thin acrylic artificial palate:
  - Resembles an orthodontic retainer
  - Generally accepted by EPG researchers that between 45 minutes and 3 hours required to *adapt* to the presence of the palate (Goozee et al., 2003; Hardcastle et al., 1991; McAuliffe et al., 2001)

- Few detailed comparisons of speech prior to, and following, palate insertion → this practise has attracted recent criticism (Weismer & Bunton, 1999)

Effect of a dental prosthesis – An overview

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- Acoustic and perceptual studies have reported a lack of adaptation using thicker palates and, generally, shorter desensitisation times:
  - McFarland et al. (1996): Retainer lowered by 3mm and 6mm in alveolar-palatal region – 15 mins of adaptation
  - Hamlet and colleagues (1978; 1979): Retainer 1mm and 4mm thick in alveolar region – increased adaptation times

- Recent perceptual and acoustic evidence to the contrary
  - Searl et al. (in press): Employed a 1mm thick dental appliance which covered palate and teeth.
  - Reported perceptual and spectral evidence of adaptation to the presence of the prosthesis following approximately 45 minutes
  - Study examined /t/ and /s/ production only

Adaptation to an EPG palate

- Individuals are considered to have adapted when:
  - Speech articulation observed by the examiner to have returned to a similar level of articulatory precision as without the palate in-situ
  - Excess salivation has ceased

- Recent anecdotal reports of the palate negatively influencing speech production in adults – particularly /s/ (McAuliffe et al., 2006a; 2006b)

- Preliminary study supported these reports, finding changes to both temporal and spectral features of consonant articulation in three normal speakers following palate insertion (McAuliffe et al., submitted).

- However, study exhibited small participant numbers, limited range of consonants investigated, and examination of consonants only

Aims and Hypotheses

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- Aim 1: Examine the effect of an EPG palate upon speech production using perceptual, temporal, and spectral measures

- Aim 2: Determine if currently used adaptation times result in articulation returning to “no palate” or baseline level

- Two possible outcomes:
  - The palate will have little effect on selected measures of articulation following a period of adaptation

    OR

  - The palate will have discernable effects upon articulation across some or all of the sampling periods

Participants and Method

- Eight young adult females (mean age = 24 years)
- Exhibited normal dental occlusion and reported no history of orthodontic treatment or neuromotor, speech, or hearing disorder
- Received a custom made “practise palate” – contains no electrodes or lead wires
- Speech production examined under four experimental conditions:
  - (1) prior to insertion
  - (2) immediately following insertion
  - (3) 45 minutes post-insertion and
  - (4) three hours post-insertion

Recording and Stimuli

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- All speech recorded using a Sony Digital Audio Tape (DAT) recorder and a uni-directional microphone (Sony ECM-3)

- Five repetitions of the experimental stimuli examined in a CVC context following a schwa:

- a teat	- a keep	- a seat	- a sheep
- a tart	- a cart	- a saab	- a sharp
- a toot	- a coop	- a suit	- a shoot

- Perceptual, temporal, and spectral analysis of the stimuli was conducted

Perceptual Analysis

- A sample of the experimental stimuli was selected for analysis
- The third repetition of five was selected → resulted in a total of 461 samples for rating (including 20% for reliability)
- Computerised perceptual speech analysis program randomly generated and played participants speech samples (O'Beirne & McAuliffe, 2005)
- Seven naïve listeners, undergraduate students, rated consonant precision on a scale of 0 (normal precision) →10 (severe imprecision)

Acoustic Analysis

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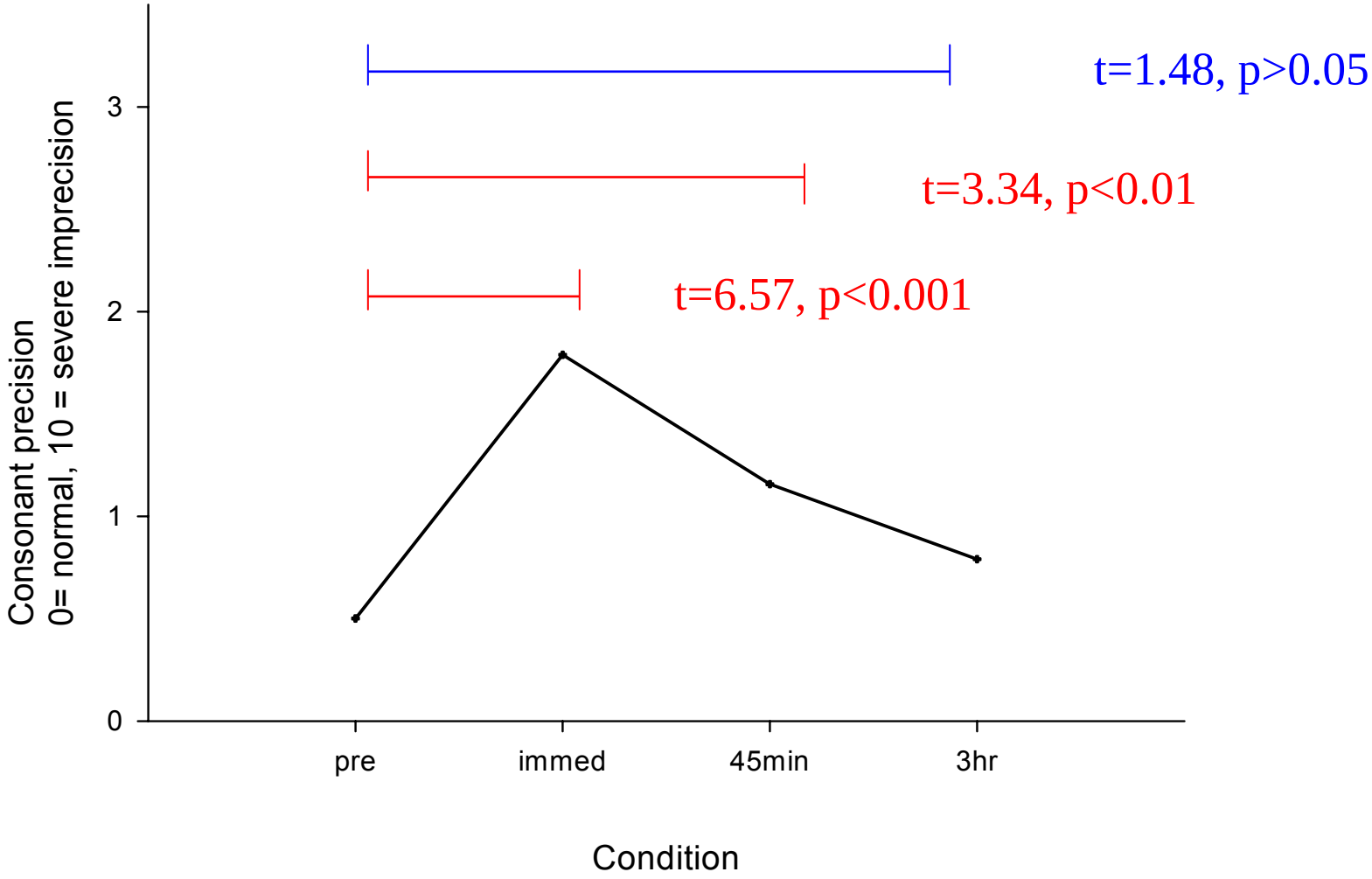
- Temporal analysis (amplitude-by-time display)
  - Consonant duration
    - Stops: voice onset time (ms)
    - Fricatives: duration of aperiodicity (ms)
  - Vowel duration: onset to offset of periodicity at level of 1st formant

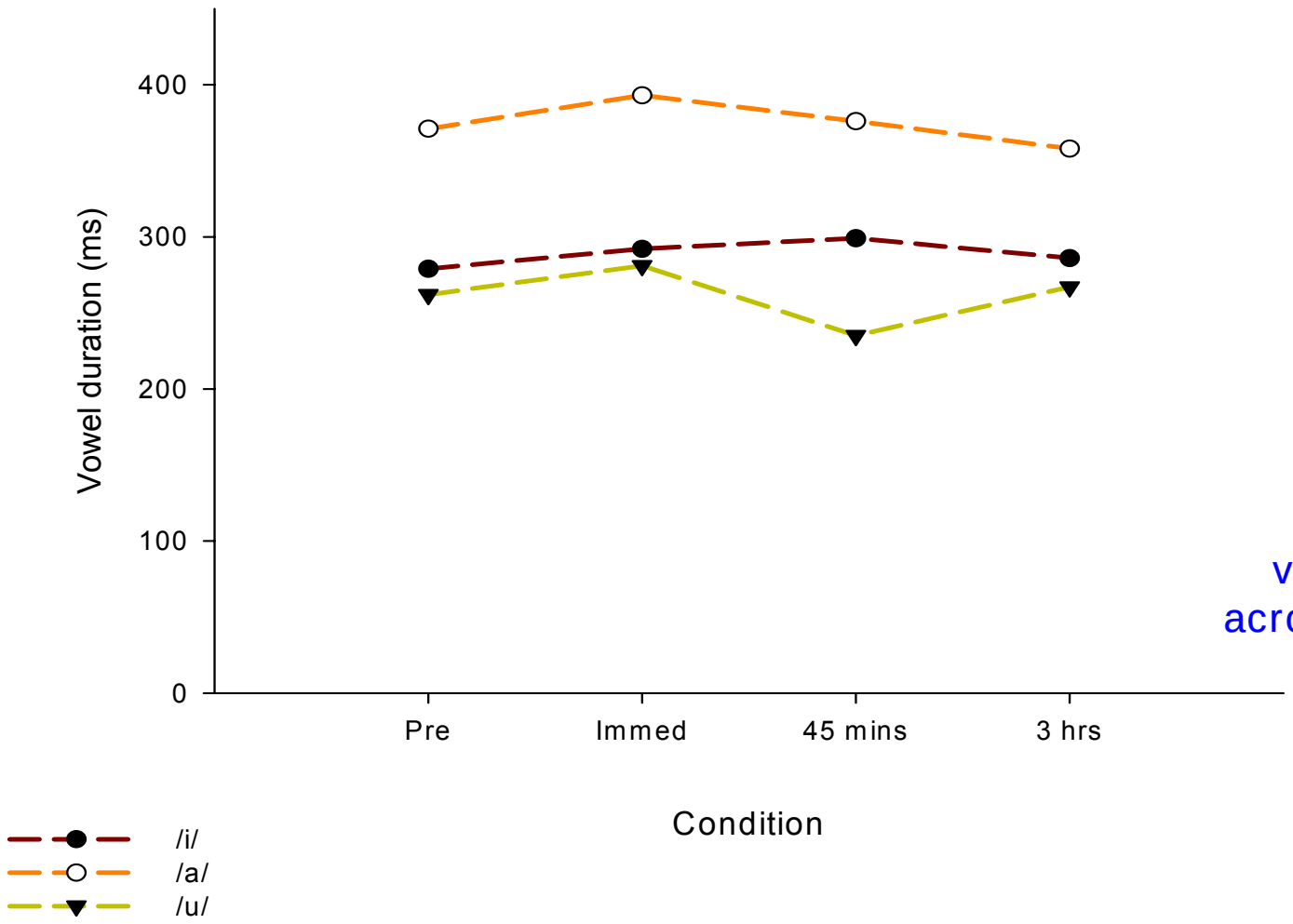
- 1st and 2nd formant frequencies: Measured over a 50ms mid-point of the vowel steady state

- Mean spectral energy:
  - Stops: a 20ms section of the consonant was selected beginning at the onset of the burst
  - Fricatives: 50ms window as positioned at the midpoint of the consonant

Perceptual Results: Collapsed across sounds

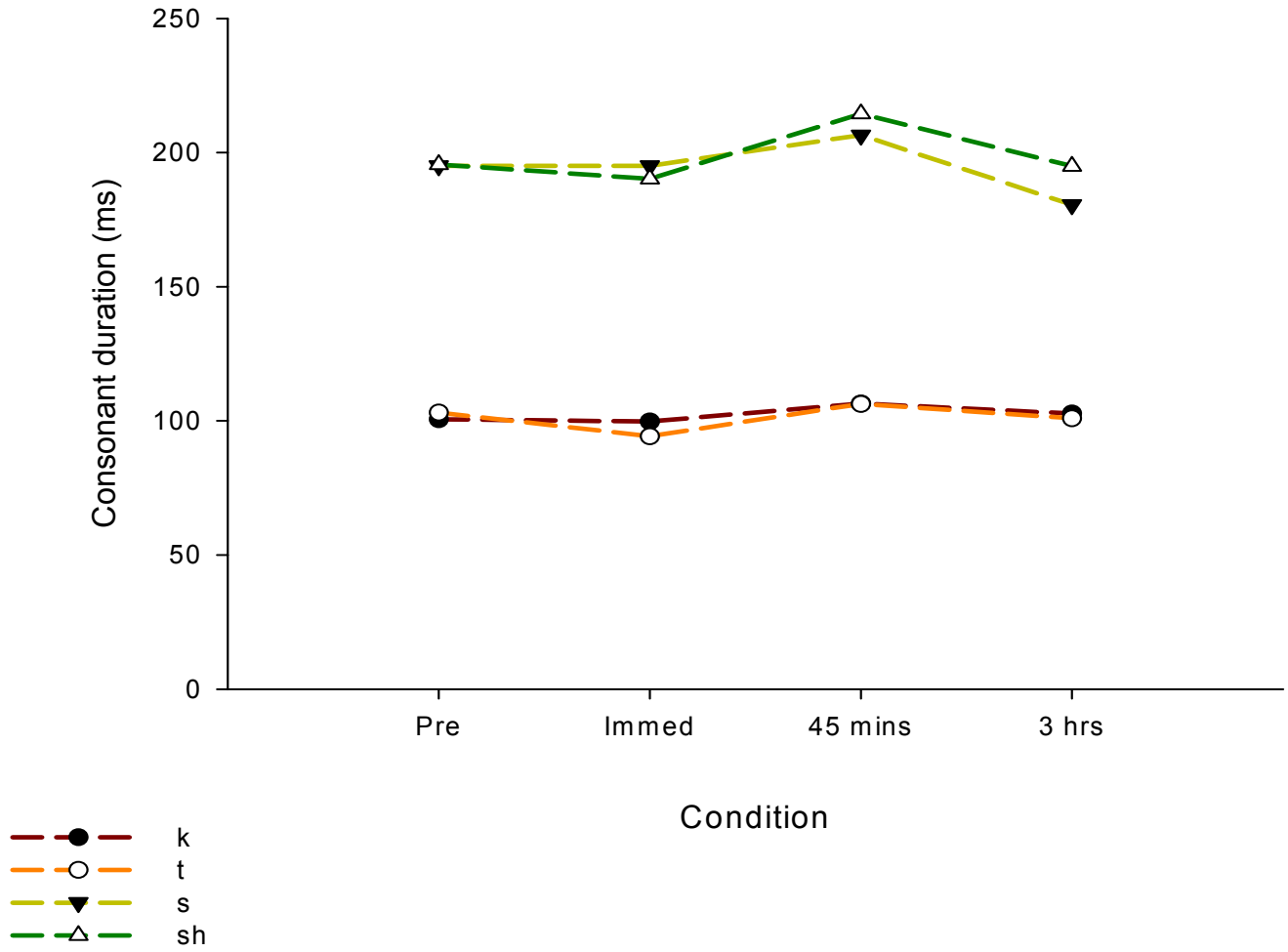


Acoustic Results – Vowel Duration



No significant differences in vowel duration across conditions

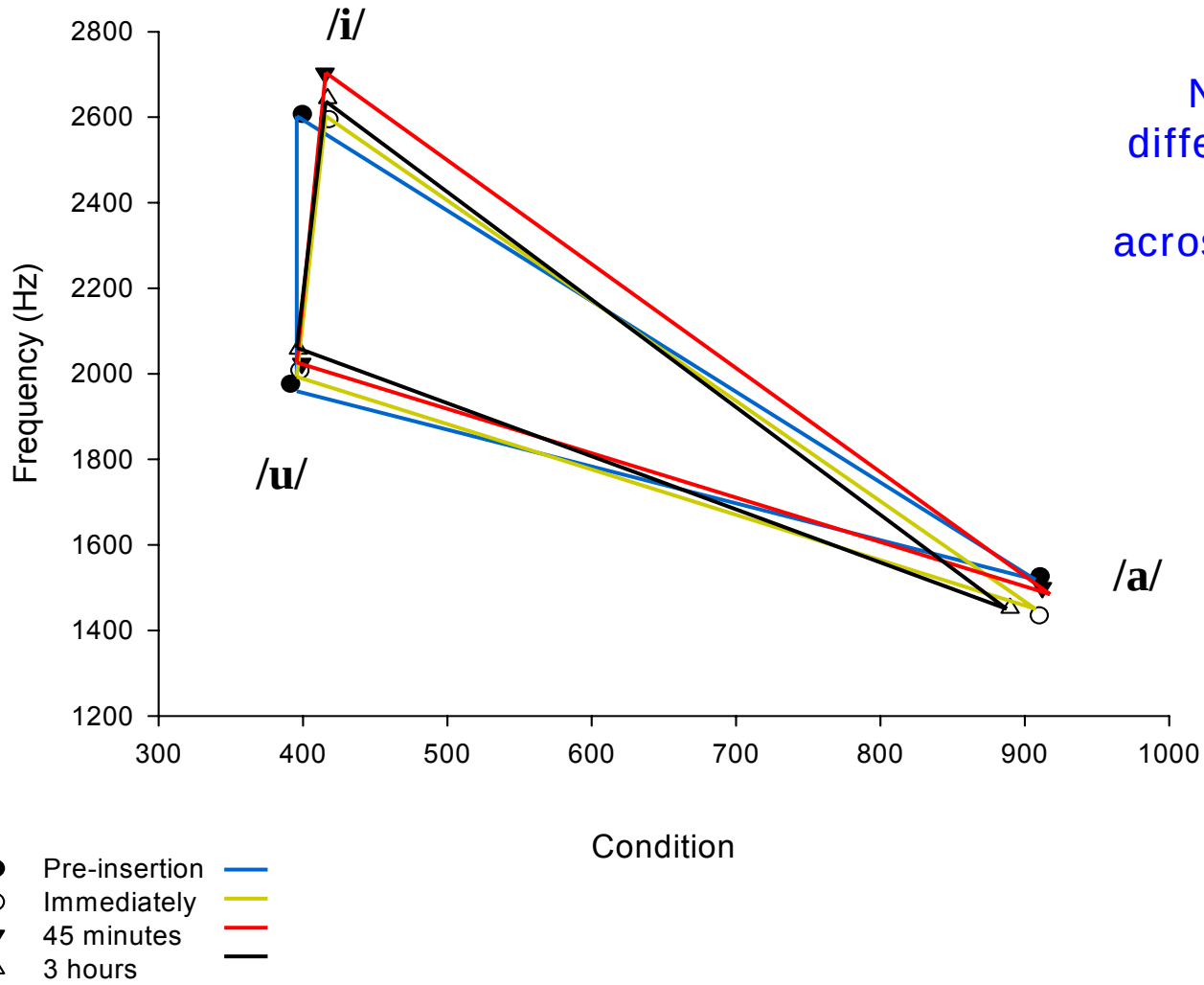
Acoustic Results – Consonant Duration



A significant increase in duration of /sh/ between the immediate and 45 minute conditions only ($q=4.38$, $p<0.05$).

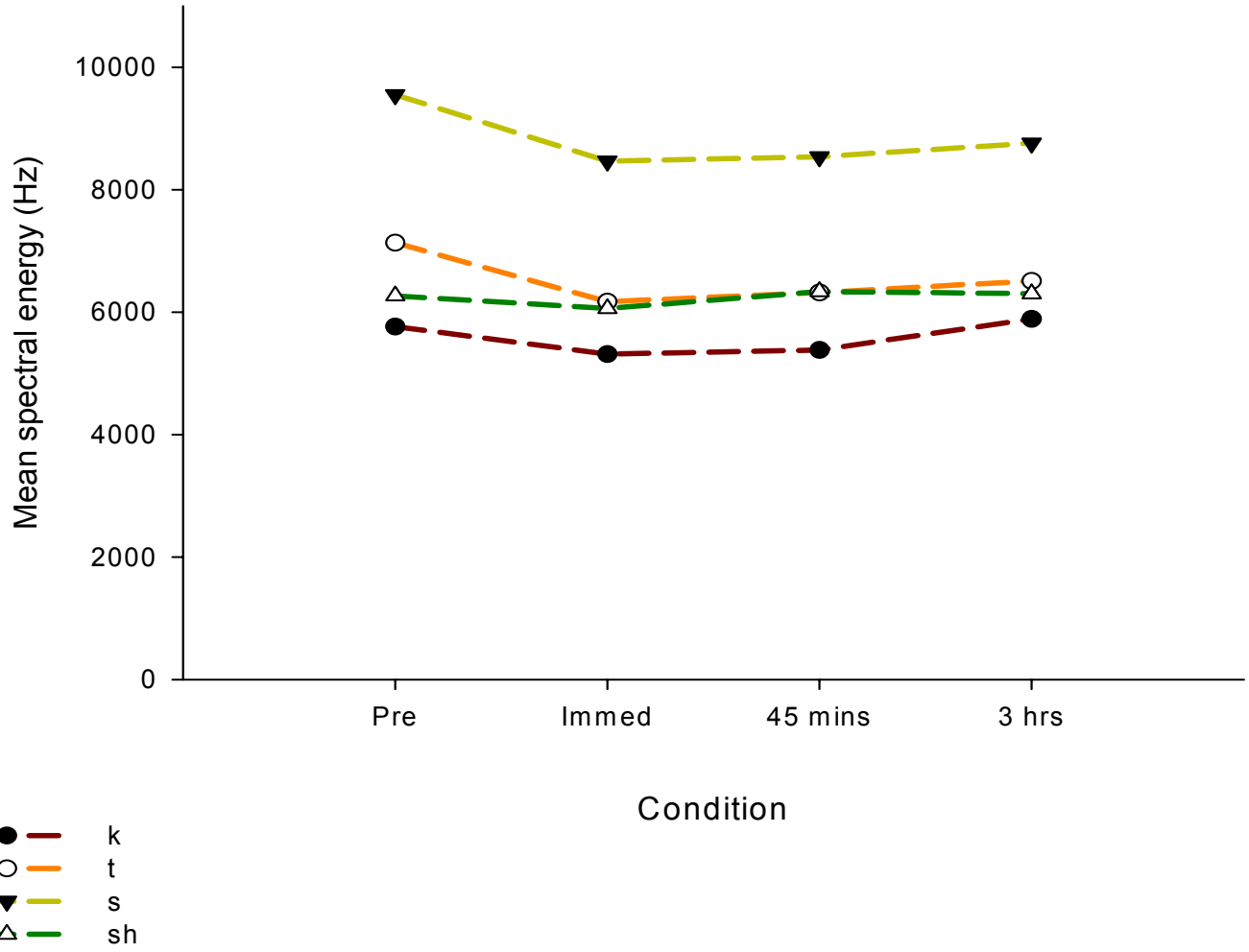
All other comparisons non-significant

Acoustic Results - F1 and F2



No significant differences in F1 or F2 values across conditions

Acoustic Results – Mean spectral energy



Significant reduction in mean spectral energy for /s/ between the pre and immediate, 45 minute, and 3 hour conditions

All other comparisons non-significant

Discussion

- Following three hours of adaptation, naïve listener's ratings had returned to baseline → a period of three hours of adaptation preferable for EPG investigations.

- Temporal measures were not affected by the insertion of the artificial palate → possible that participants exhibited conscious control over segment duration, compensating for the changed articulatory conditions.

- Vowel formants were not altered by presence of palate → possible that participants had greater jaw lowering to maintain perceptual quality of vowels

Discussion

- Spectrally, results indicated that the palate negatively affected /s/ articulation. It is likely that two factors are responsible for this finding:

  (1) The high level of lingual precision required for /s/ production

  (2) Articulation in the alveolar region of the palate

- Limitations of the present investigation: Small participant numbers and examination of adaptation in single word context only.

Acknowledgements

- Motor Speech Research Centre, University of Queensland
- Yan Cheng, University of Queensland
- Sue Barrowman and Kate Sutherland, University of Canterbury
- Bachelor of Speech-Language Therapy students, University of Canterbury, who competed the perceptual analysis
- Dr Greg O'Beirne, University of Canterbury

References

- Carter, P., & Edwards, S. (2004). EPG therapy for children with long-standing speech disorders: predictions and outcomes. *Clinical Linguistics and Phonetics, 18*, 359-372.
- Gibbon, F. E., Dent, H., & Hardcastle, W. J. (1993). Diagnosis and therapy of abnormal alveolar stops in a speech-disordered child using EPG. *Clinical Linguistics and Phonetics, 7*, 247-268.
- Gibbon, F. E., McNeill, A. M., Wood, S. J., & Watson, J. M. M. (2003). Changes in linguapalatal contact patterns during therapy for velar fronting in a 10-year-old with Down's syndrome. *International Journal of Language and Communication Disorders, 38*, 47 -64.
- Goozee, J. V., Murdoch, B. E., & Theodoros, D. G. (2003). Electropalatographic assessment of tongue-to-palate contacts exhibited in dysarthria following traumatic brain injury: Spatial characteristics. *Journal of Medical Speech-Language Pathology, 11*(3), 115-129.
- Hamlet, S. L., Cullison, B. L., & Stone, M. L. (1979). Physiological control of sibilant duration: Insights afforded by speech compensation to dental prostheses. *Journal of the Acoustical Society of America, 65*(5), 1276-1285.
- Hamlet, S. L., & Stone, M. L. (1978). Compensatory alveolar consonant production induced by wearing a dental prosthesis. *Journal of Phonetics, 6*, 227-248.
- Hardcastle, W. J., Gibbon, F. E., & Jones, W. E. (1991). Visual display of tongue-palate contact: Electropalatography in the assessment and remediation of speech disorders. *British Journal of Disorders of Communication, 26*, 41-74.

References continued

- McAuliffe, M. J., Lin, E., Robb, M.P., & Murdoch, B.E. (submitted). Influence of a standard electropalatography artificial palate upon articulation: A preliminary study.
- McAuliffe, M. J., Ward, E. C., & Murdoch, B. E. (2001). Tongue-to-palate contact patterns and variability of four English consonants in an /i/ vowel environment. *Logopedics Phoniatrics Vocology, 26*(4), 165-178.
- McAuliffe, M. J., Ward, E. C., & Murdoch, B. E. (2006a). Speech production in Parkinson's disease: I. An electropalatographic investigation of tongue-palate contact patterns. *Clinical Linguistics and Phonetics, 20*(1), 1-18.
- McAuliffe, M. J., Ward, E. C., & Murdoch, B. E. (2006b). Speech production in Parkinson's disease: II. Acoustic and electropalatographic investigation of sentence, word and segment durations. *Clinical Linguistics and Phonetics, 20*(1), 19-33.
- McFarland, D. H., Baum, S. R., & Chabot, C. (1996). Speech compensation to structural modifications of the oral cavity. *Journal of the Acoustical Society of America, 100*(2), 1093-1104.
- O'Beirne, G., & McAuliffe, M.J. (2005). Perceptual speech analysis program. University of Canterbury, Christchurch, New Zealand.
- Searl, J., Evitts, P., & Davis, W. J. (in press). Perceptual and acoustic evidence of speaker adaptation to a thin pseudopalate. *Logopedics Phoniatrics Vocology*.
- Weismer, G., & Bunton, K. (1999). Influence of pellet markers on speech production behavior: Acoustical and perceptual measures. *Journal of the Acoustical Society of America, 105*(5), 2882-2894